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Research Paper

Specific And Generic Skills in Architectural Geometry Teaching: Review And New Developments

Mathematics

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ABSTRACT

The work is devoted to exhibit how teaching methodology and learning activities experience a deep change in architectural geometry teaching when considering specific and generic skills in the teaching-learning process. These skills are not limited to technical skills, but actually reflect the competences which are claimed in the world of work nowadays.

INTRODUCTION

In the present work, the authors aim to exhibit how teaching has suffered a conversion in the subjects of geometry and mathematics in the Degree in Architecture, in the University of Alcalá (Spain). Both disciplines cohabit, interchange ideas and benefit one to each other shaping a pioneer and innovative pattern of teaching as befits the current trends in education.

In such a new sophisticated discipline, both, mathematics and architectural geometry share general and specific skills that have to be developed in a joint manner. Some of these of general nature include argumentative skills, the development of a logical, analogical and deliberative thinking, etc... Also, a student should achieve more specific skills connecting these two areas of knowledge such as spatial and visual skills, the manipulation of geometrical concepts in order to apply them in architectural works, the achievement of a theoretical and abstract knowledge of the mathematical results and equations where the graphical techniques lean on, the use of symbolic computation and graphical representation software,... This work aspires to focus on some generic skills such as the effective problem solving, the decision making, the competence to work in multidisciplinary teams, the development of creativity, of an efficient and effective (oral and written) communication process, the acquisition of ethical principles, versatility on the approach,...

The actual world of work requires professional qualifications in which all of these skills must have been built up in advance in the future worker. It is a major task for the university to provide graduates owning such skills and, consequently, some specific actions have to be developed by universities and enterprises in this direction.

Within the adaptation of the Spanish education system by Bologna Process, several new teaching methodologies appear. Some of them are coming from the English model of higher education or even from the world of work itself: the case method, the project-based and the problem-based learning... and all of them are adapted for educational purposes. From the experience obtained by some university teachers after some years of adaptation to the new widespread way of teaching, the learning-teaching process has suffered a change. Some of these experiences can be found in numerous references and examples where one can find helpful tips and theories in order to achieve the acquisition of such skills. From the point of view of the enterprises, they are dealing with qualitative and quantitative methods (such as tests, directed interviews...) for their recruitment proceedings. In addition to this, it is common to find goal directed project management in several companies. On the contrary, these methods are not still celebrated for some reasons such as the ratio of students to teachers at university which would make them impossible to implement. For this and other reasons some university teachers are building up specific tools for collecting data and developing mechanisms such as scoring rubrics. In our particular case, we have developed observation forms with the help of specific rubrics containing the skills to achieve. Over the past few years, a group of teachers in the degree of architecture has been supporting several actions on the education development and interdisciplinary in these studies. The methodology used in the teaching-learning process is revised and evolves continuously every year in such a way that the skills achieved by a graduate student are not reduced to technical skills, but also to a great range of other generic and specific skills and competences. It is clear for us that every resource used in the teaching-learning process must be developed and improved in agreement with the skills that a student is assumed to acquire throughout the studies of architecture. Sometimes, we will focus our attention on a specific subject to clarify some of the activities accomplished dealing with this methodology: Architecture Drawing Workshop II (Taller de Dibujo II, in Spanish. We write TDII for short).

As it was pointed out in the introduction, one could describe in detail generic and specific skills we deal with. In the present work, we only give details on some of the generic competences we aim to enhance and make our students achieve.

2 TEACHING-LEARNING METHODOLOGY:

Tuning process [15] maintains that generic competences are distinguished into three types. Namely, instrumental competences (cognitive abilities, methodological abilities, technological abilities and linguistic abilities), interpersonal competences (individual abilities like social interaction) and systemic competences (autonomous work, adaptation abilities to new settings, initiative abilities, entrepreneurial spirit...). One can also find some detail on the competences developed by some of the most prestigious universities all over the world [11].

In the following subsections, we enumerate and give a brief explanation on the generic skills we intend to describe for they play a crucial role for the methodology used for promoting the professional skills needed in the world of work. Clearly, any educational activity which makes a particular generic skill improve in a student also provides some progress in other related general skills. Moreover, it is required that every student departs from a suitable level of development in some competences at the moment of taking part in an educational activity focused on the improvement of a certain generic skill. For example, the development of autonomous work in a student needs somehow

some problem solving, responsibility, critical reasoning, self-confidence, be accustomed to the use of information and communications technologies (ICT), etc... and also, the improvement of autonomous work entails some development of communication skills such as verbal and written communication, decision making process, entrepreneurial spirit and the ability of adaptation to new situations, among others.

- **The ability of adaptation to new situations:**

This skill can be defined (following [6]) to be the systemic competence through which a student acquires a kind of flexibility in his learning process. A student who has reached this ability is not limited to a single work direction or to deal with a task which has already become accustomed to. Indeed, such a student has a fair disposal to challenges and integrates easily any novel skill or information which is been provided.

From the point of view of a teacher, this skill seemed crucial to us when regarding a future incorporation in the world of work of a graduate student. The world of work suffers a constant change and would surely request a high level of adaptability to different and novel tasks for the inexperienced. One of the educational activities in the scope of this skill in the course was the first project for the students. At the very beginning of the academic year, most of the students in our course ignore graphical computer software such as 3DMax, AutoCAD, Rhinos... and do not know anything about mathematical software such as Maple. At the end of the course, any student of TDII ought to have learnt, at least, one of each in the previous software in order to be able to create their own makings. For the first weeks, the students start to learn how to work with them, but it might not be enough time for them to turn self-confident enough to embrace them as a known tool. Taking advantage of this situation, the teachers of TDII ask the students for a first project to be carried out, using these mathematical and graphical computer software.

This turns out to be an excellent opportunity for us to enhance the ability of adaptation to new situations in our students. Of course, this first project entails worse results from the point of view of the final product, but this is not the main purpose. One has to be aware of several risks involving this educational activity, guiding each student towards the objective. At this point, students experience some frustration, so it is decisive in the teaching and learning process to pay attention to the needs of each student achieving balance in this challenge. Without going into detail in the possible topics for the different projects, it is worth saying that the evaluation criteria are adapted to the circumstances. The students are also aware of the importance of being able to get used to new tools of work rather than the perfection of the final product. We believe it is crucial the implication of the teacher in this kind of activities not to cause frustration in the student, and also the implication of the student, predisposed to learn new techniques with an open mind.

One can stress some of the indicators measuring the degree of development of the ability of adaptation to new situations such as the degree of employment of information to reach the objectives, the adjustment to the knowledge available at a moment, the acceptance of changes in the environment, the identification of novel demands and opportunities and the capability of assuming new tasks.

One can point out other related skills such as self-confidence which are developed while working with the ability of adaptation to new situations.

- **Decision making:**

This skill is closely connected to the previous one. One has to make decisions in order to get adapted to the new situation when facing a new challenge. This competence deals with the internal process of making an appropriate choice among several alternatives, individually or in a group. Modern society expects everyone to be able to take adequate decisions being coherent with their scope and being conscious of the consequences (see [14]). It is required for this skill to be enhanced by anyone that critical reasoning among other skills is sufficiently developed and acquired to obtain successful results in the educational activities held.

Regarding our particular case in TDII, we provided the students several situations and activities where they could develop this skill, making decisions by choosing among several options. For instance, we recall the first project in TDII, where the students could make a choice with respect to some aspects. Depending on the decision taken, a student could assume some hypotheses on the project which made it easier to handle. If a student made the decision of been benefit of this help, his maximum score suffered a conscious decrease.

Throughout the course, the students were asked to perform a long project. Each student chose among more than forty different possible topics: authors, buildings, artistic trends, geometrical abstract objects, etc... The decision making skill was not promoted only regarding this choice. In fact, every student was free to decide the point of view from where the work would be treated. In this concern, works were very different from one to other, even if the topic was the same one. In addition to this, we tracked how the projects were been building to redirect and guide students who had not achieved an appropriate perspective or development for it.

- **Innovation and creativity**

This competence can be placed between the so called instrumental competences and the systemic ones. The point in common with the first one can be seen to be related to a cognitive competence, seen as creative thinking, whether the inclusion in the second group is more related to innovation. Roughly, creativity turns out to be the skill to create new products or ideas (from another idea or product or even from the very beginning). Meanwhile, innovation is the action through which a novelty is put in a process, generating a better product (from [12]).

The long project in TDII heads towards a last part of the project which is concerned with innovation and creativity. After two project deadlines (where the students had to develop specific skills related to mathematics, architectural design, or both of them), in the final checkpoint of the long project, the students were asked to go further in the work and provide a new creation departing from what they had learnt so far.

- **Other skills and evaluation method**

We have tried to emphasize throughout this section how the subject TDII was constructed around the idea of enhancing and developing skills and competences which turn out to be crucial in the world of work today. We have paid attention to three of them, but we could have gone further giving details on the activities held in order to value the degree of development of each of the competences enumerated at the beginning of the current section. The way to measure the benefit the students register in the different skills is made by means of scoring rubrics and, quantifying this benefit. As an example, here are some points taken into account when dealing with evaluation of the competence "information management" evaluating the long project in TDII. It is worth remarking that the rubric may change in some points depending on the nature of the work under review: an au-

thor, an artistic trend,... but it has remained unchanged regarding some skills such as this one. We provide some of the questions in the rubric taking into consideration this skill:

- Does the student search and try to find the main points in the topic of the project?
- Was the student able to find appropriate sources of information by himself/herself?
- Did the student use a variety of sources of information such as Internet, textbooks, monographies,...?
- Did the student use Internet as a source of information?
- Did the student use of research papers as a source of information?
- How adapted is the information provided in the project to the topic of research?
- Does the student provide a bibliography?
- ...

ACTUAL BENEFITS OF THE APPROACH FOLLOWED FOR PROMOTING PROFESSIONAL SKILLS:

In the present academic year, we have mainly dealt with two difficulties regarding the development and assessment of competences: on one hand, how to choose a way to develop them, and on the other hand, how to evaluate the students throughout the process. We concluded that both should be answered in a common manner.

It is crucial in the development of competences to establish at the beginning of the educational process which goals one aims to achieve, and what aspects are going to be taken into consideration when evaluating a student. For this reason, the evaluating process plays a significant role from the starting point in the subject. If one sets specific tools in advance in order to identify and develop competences, every student would be provided with adequate information on how to build up each and every skill.

The method used, based on qualitative techniques, has to approximation levels; on one side by working with qualitative tables of indicators based on a binary system (a parameter is/is not accomplished) , and on the other side, a more complex system, based on rubrics, leading to four different levels of attainment of simple objectives. One can quantify the evaluation of a student by adding up these different issues.

Both assessment systems turn out to appreciably improve the traditional quantitative system of numeric evaluation, quite low-skilled, and they rest on the development of the competences a priori, and also on the evaluating elements involved. Nowadays, the evaluation process, considered as a penalty system on the qualification acquired by a student, has been demoted to specific processes in which a few number of candidates are to be chosen, but they do not remain valid for educational approaches.

For this academic course, we chose some of the skills among the ones listed in the present paper to work with. For practical reasons we decided to focus our attention only on two or three skills per course, and change them alter the course, if necessary. It is not easy, nor educationally reasonable, to try to work with more than two competencies at the same time.

For each competence we proceed to search for those indicators we considered essential to be developed and we provided several tables in order to facilitate the follow-up of each student day by day and in the final work. For its accomplishment, we followed the publication of Terrón et al., [13], where a wide amount of competencies have been studied from the point of view of rubrics and indicators.

The table for the skill Decision Making corresponds to the incoming one:

TABLE – 1
Indicators for the skill Decision Making

INDICATORS	es	o
Identifies different alternatives before taking a decision.		
Collects the information needed to decide		
Makes a list with advantages and disadvantages of each option.		
Raises how to solve or reduce disadvantages of each posed option		
Capacity Utilization (Estimated)		
Growth in Truck & Bus tyre production		
Wonders whether a chosen option involves the advantages of other alternatives.		
Allocates an assessment to every advantage and disadvantage of each posed option.		
Allocates the emotional and relational cost of each posed option.		
Takes into account the advices and critics of teachers and other students to improve in decision making.		
Makes the decision and gives reasons to it.		

Source: [13], pp.142-143

At a glance on Table 1, one can appreciate whether a student has acquired the skill. It provides a useful approach to the assessment of skills and competences for a non-expert teacher or when evaluating a large group. However, it does not provide complete information on the student's teaching and learning process. At this point, we made use of a rubric table, such as the following one for the skill "Creativity".

TABLE_ 2:
Rubric for the skill Creativity ([13], pp. 105-106)

INDICATORS	1	2	3	4
Queries the standard and/or established procedures.	Does not query about the situation. Follows the procedures established literally, without questioning anything.	Raises whether there exist other ways to proceed but does not arrive to any alternative procedure.	Raises traditional statements and is able to transmit the others about new thoughts.	Generates numerous alternative ideas for proceeding, staying ahead of external requirements.
Can assume to develop new activities without previous knowledge.	Is not able no assume new activities. Needs models, guides,... to start working.	Tries to deal with new projects and can express difficulties when searching solutions around.	Assumes new activities and search for a solution in an active manner.	Assumes every proposal as a challenge and enjoys dealing with activities where nothing is given in advance.
Can express and transmit novel ideas and takes them into practice.	Is not able to transmit ideas not applying them.	Is not able to express ideas fluently and has difficulties when taking them into practice.	Is able to transmit ideas and make others understand them. Can search for applications to other problem.	Is able to apply creative ideas to enhance results. Provides creative thinking to others with attitude.

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FUTURE ISSUES AND CONCLUSIONS:

We feel satisfied with the results obtained so far. The teachers have observed the students achieve competences on several skills that will be useful in the world of work. Under our point of view, these ones would not have been obtained if we had followed the traditional way of teaching. It is not possible for us to compare results regarding this novel procedure and another one for the subject is novel in the degree of architecture. However, it is worth saying that teacher surveys held after the course show that most of the students agree with this way of dealing with the subject. Specifically, they emphasize that the students become interested on the subject from the very beginning, and teachers' disposal to cater for the student's necessities. 90-95 % of the students pass the subject.

The experience shown in the present work is not concluded yet. As it can be observed from the foregoing sections, the system suffers a refinement continuously. The results from previous courses would provide the experience to revise the procedures followed and also to add some other educational tools in the teaching and learning process. Some skills on which we focus our attention are been added to it, and some others are erased or altered from the initial ones, accordingly.

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